Control Measure to Reduce Emissions from Off-Road Large Spark-Ignition (LSI) Engines

June 23-24, 2005: Fresno, California

What are “Large Spark-Ignition Engines”?

- Gasoline and LPG
- Older automotive technology
- Greater than 25 hp and 1 liter
- Mainly industrial equipment
- Typical life of 7-11 years

Examples of LSI Equipment

- Forklifts

Examples of LSI Equipment

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- Airport ground support

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- Sweepers/scrubbers
- Industrial tow tractors

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- Generator sets

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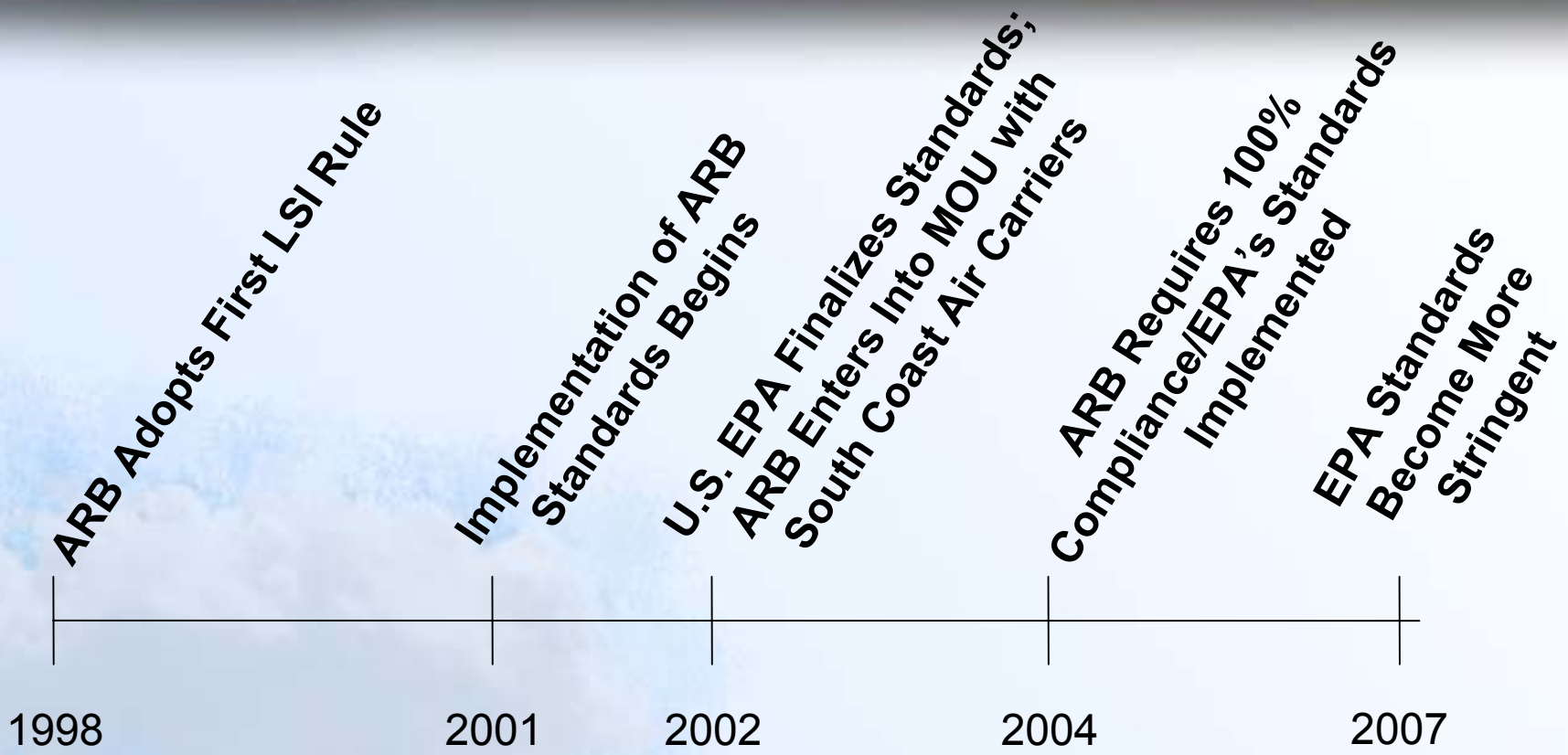
Examples of LSI Equipment

- Forklifts
- Airport ground support
- Sweepers/scrubbers
- Industrial tow tractors
- Generator sets
- Turf care equipment
- Other non-preempted industrial, construction, and agricultural equipment

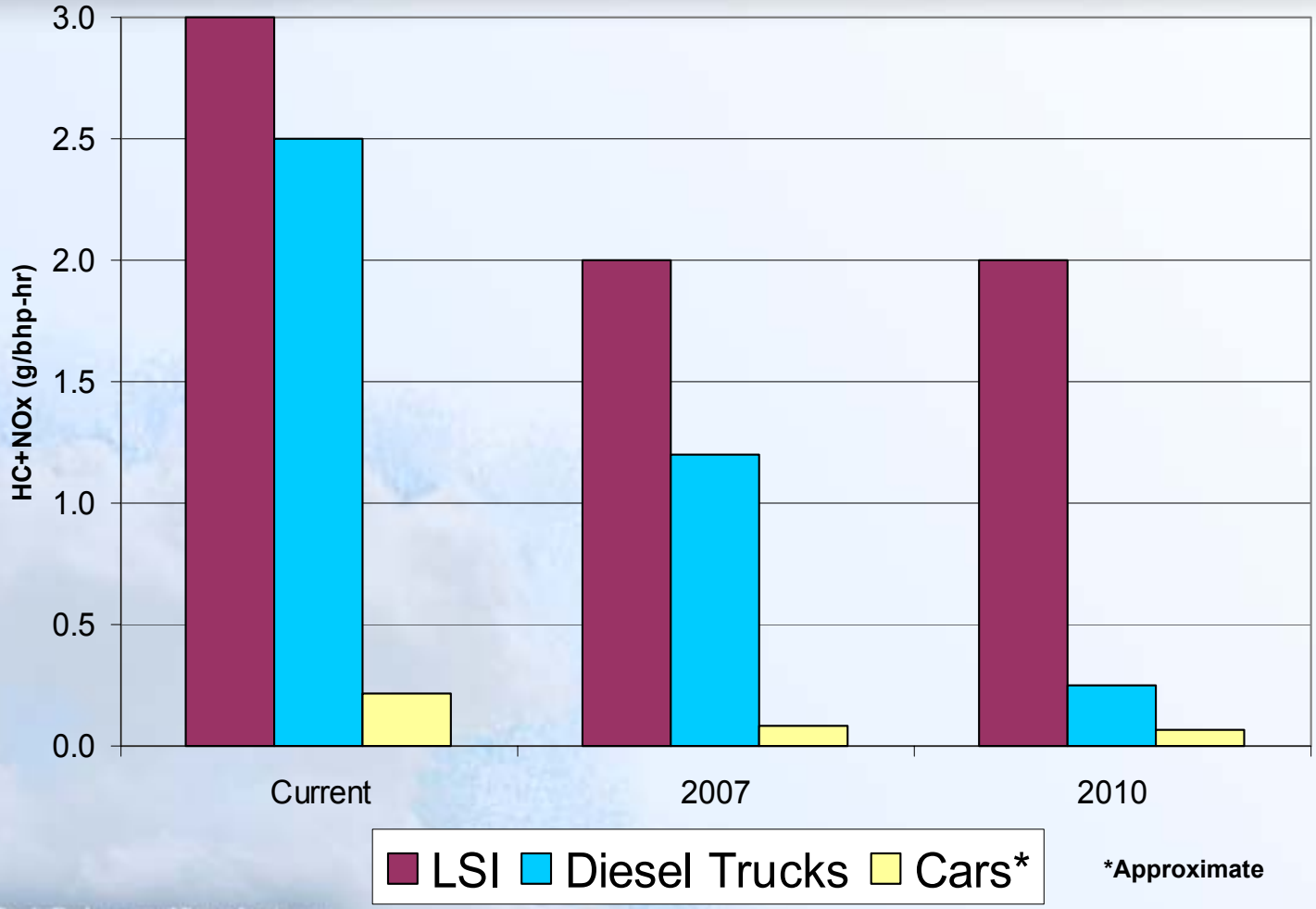
LSI Emissions

- 88,000 LSI engines
  - 40,000 forklifts
- HC+NOx emissions:
  - 70 tons per day in 2004
  - about 5 percent of off-road mobile source emissions

History of Control



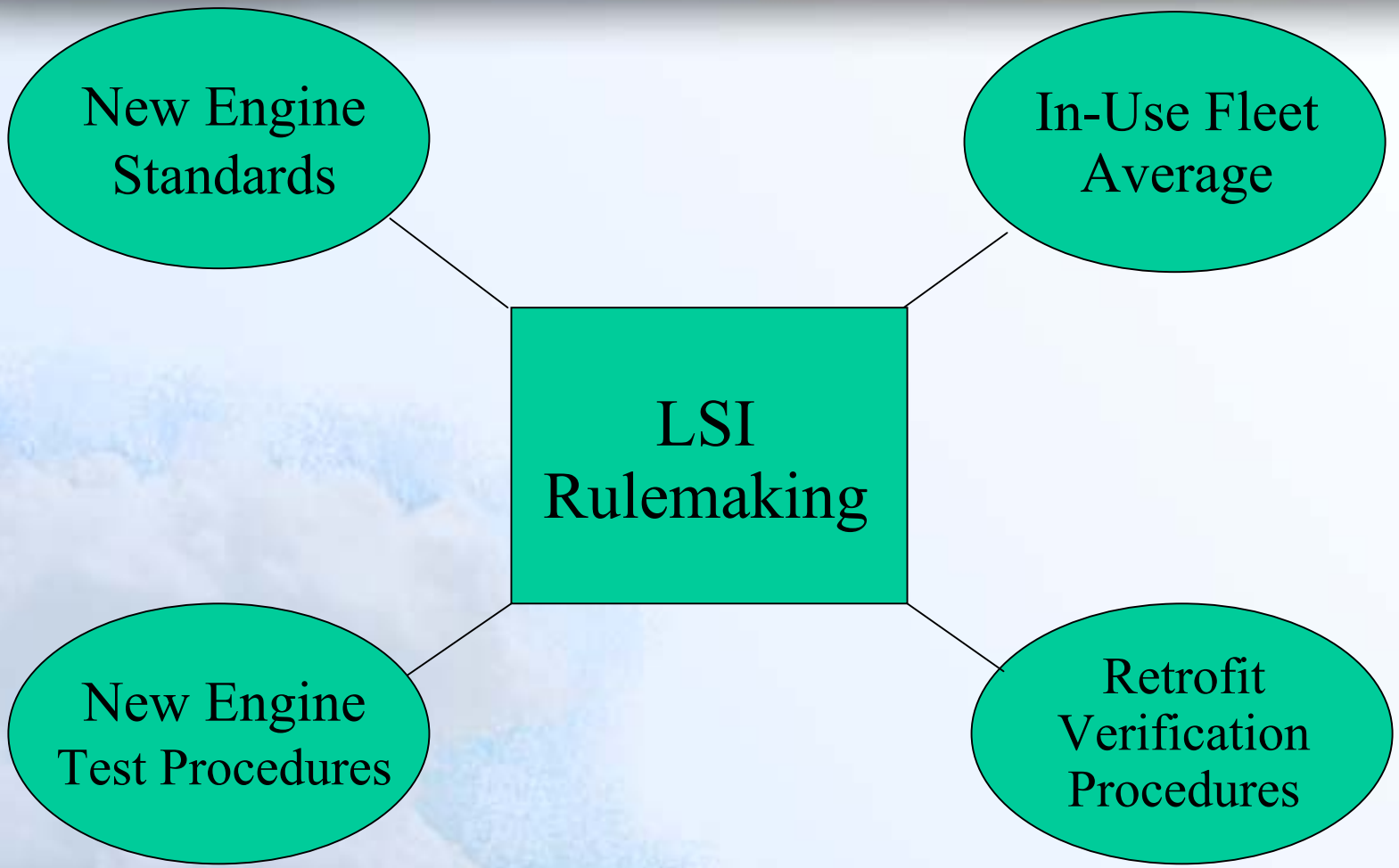
Comparative Emissions



2003 State Implementation Plan Commitment

- SIP Measure LSI-1
  - harmonize with 2007 EPA new engine standards
- SIP Measure LSI-2C
  - consolidates two proposals:
    - Existing engines - reduce emissions by 80%
    - New requirements incorporating zero- and near-zero-emission technologies
- Goal - reduce statewide HC+NOx emissions
  - 6 to 13 tons per day by 2010

Elements of the Proposal



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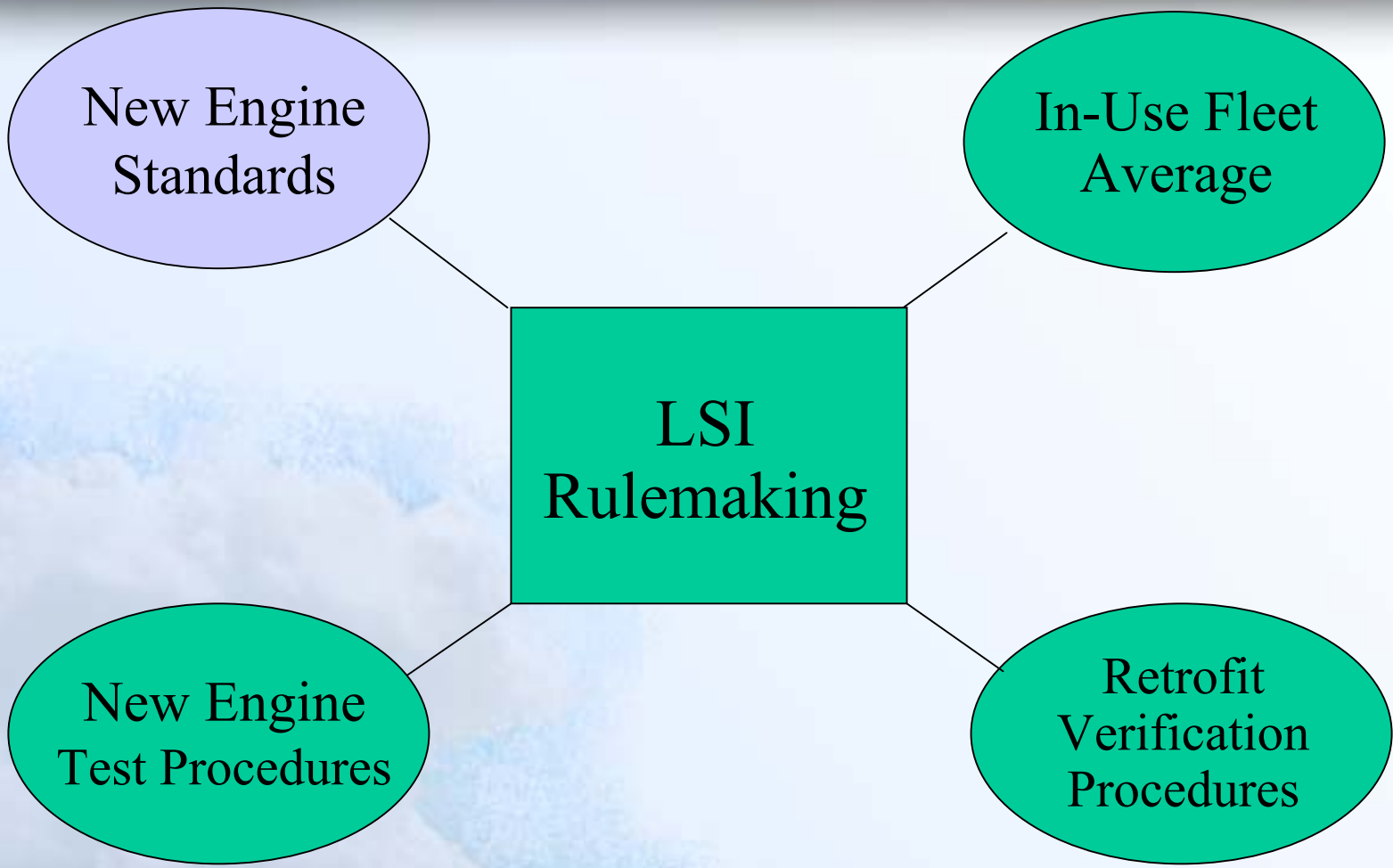
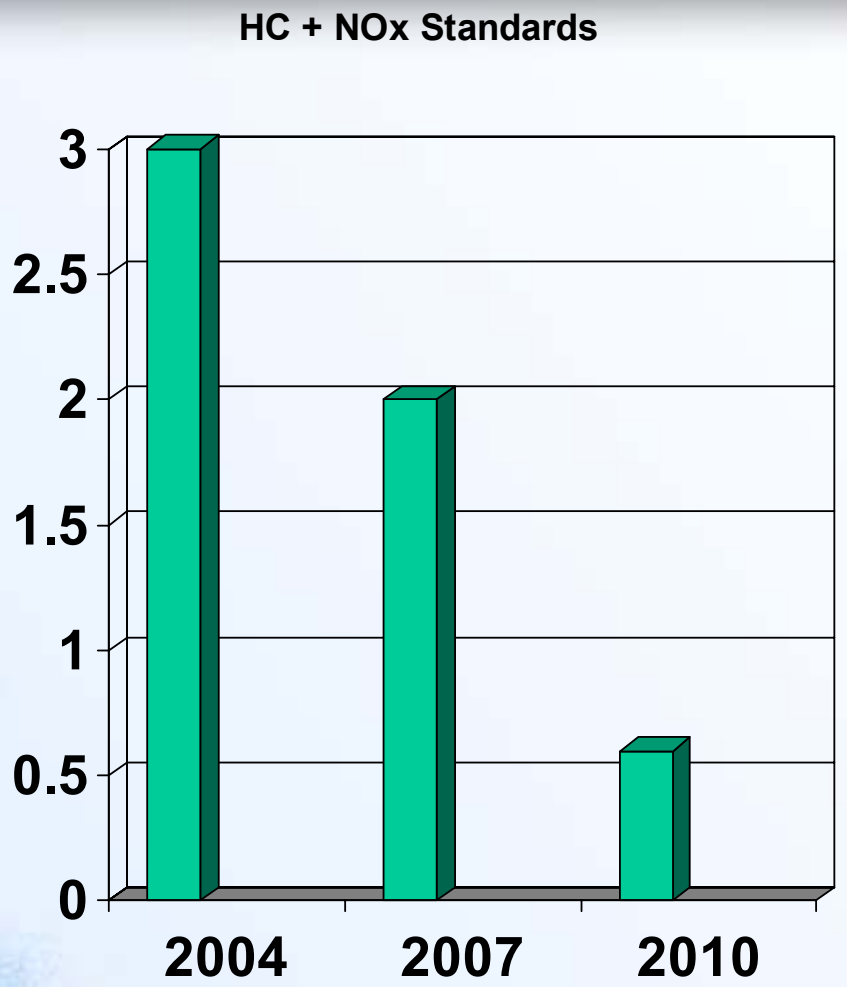


Proposed New Engine Standards

- 2.0 g/bhp-hr HC+NOx in 2007
  - Aligns with EPA
- 0.6 g /bhp-hr HC+NOx in 2010
- Draw upon automotive emission control technology



Technology Comparison

	2004 Forklift	2010 Forklift*	Typical 2004 Car
Fuel System	Carb/TBI	TBI/SMPI	SMPI
Catalyst Volume (% of engine)	40%	80%	100%
Grams of Pt	0.77	> 2	> 2
Grams of Rh	0.19	> 0.4	~ 2
Cert. Emissions (HC+NOx g/bhp-hr)	1	0.1 – 0.3	0.06**
Emission Std. (HC+NOx g/bhp-hr)	3.0	3.0	0.15**

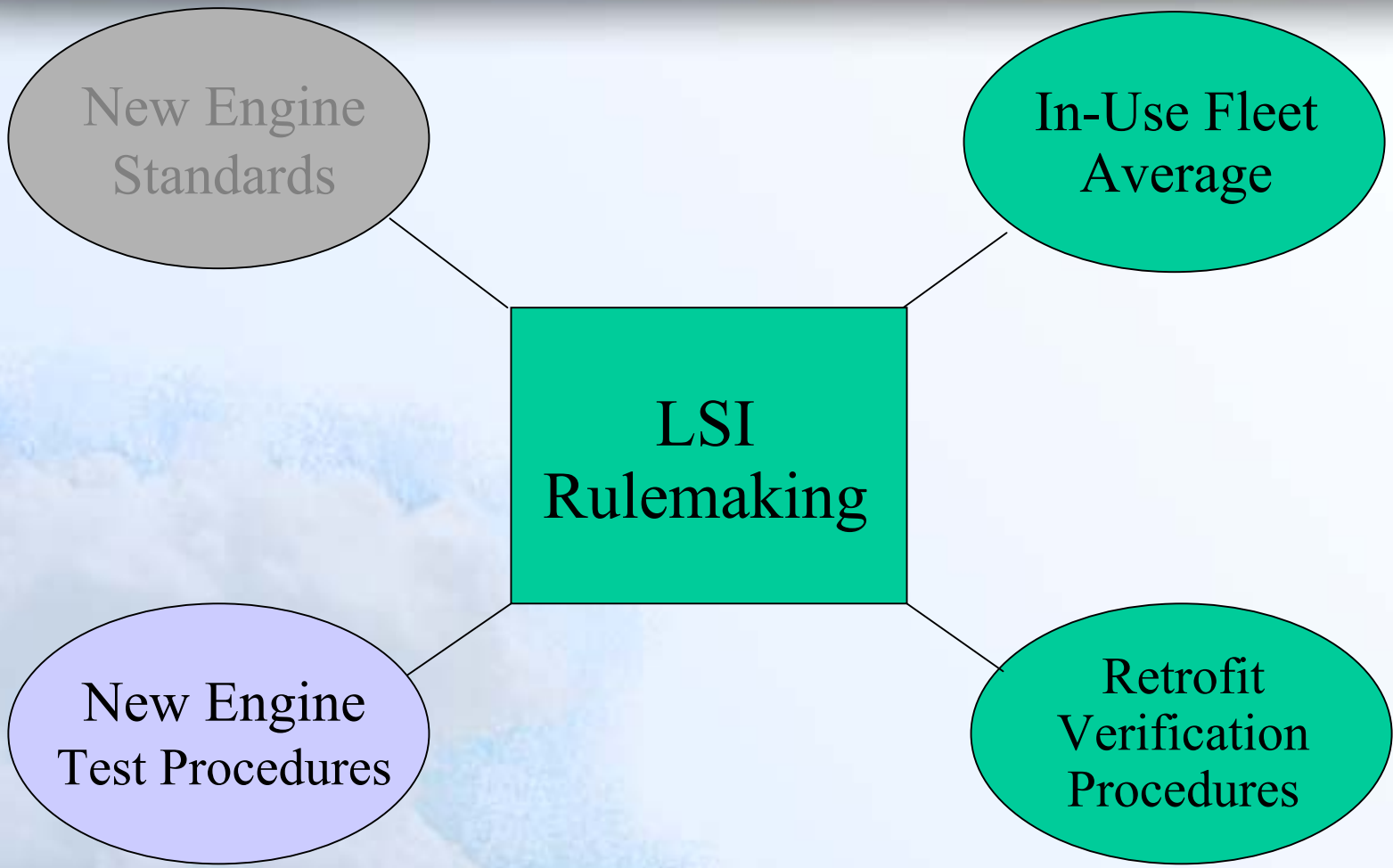
*Based on cleanest model available today

**Approximate

Optional Manufacturer Lower Emission Standard

- Optional Tiered Certification
  - Model year 2007 and later
  - Early use of available clean technologies
  - Certify to 1.5, 1.0, 0.6, 0.4, 0.2 and 0.1 g/bhp-hr
  - Credits
  - Possible Carl Moyer funds

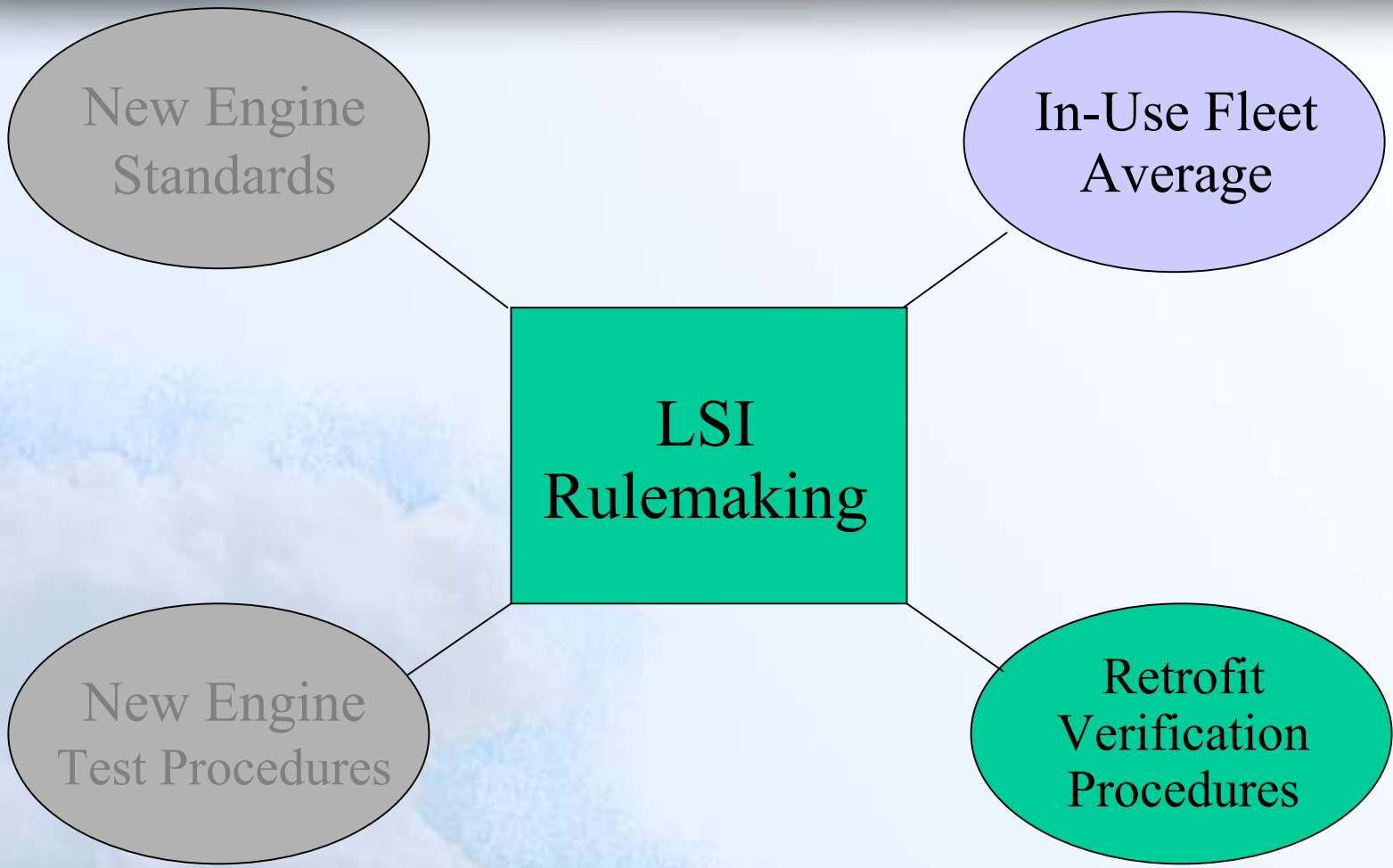
Elements of the Proposal



New Engine Test Procedures Beginning in 2007

- Regulatory proposal incorporates federal test procedures and compliance provisions with minor modifications
  - labeling, warranty, durability, field testing
- U.S. EPA released revised requirements on June 3, 2005
- Staff recommends that the ARB align with new EPA procedures where possible
  - provide ample time for review and comment
  - notify Board of any significant issues

Elements of the Proposal



Fleet Average Concept

- Applies to
  - operators of forklifts, sweepers/scrubbers, tow tractors, and airport ground support equipment
  - owned equipment; rental/lease greater than one year
- Achieves declining fleet average emission level
  - Retrofit or replace uncontrolled LSI equipment by 2009
  - Replace some LSI with cleanest LSI or zero-emission equipment
- Standards vary by fleet size and type of fleet

Fleet Average Standards

(Fleet Average Emission Level in Grams HC+NOx)

LSI Fleet Type	Number of units	By 1/1/2009	By 1/1/2011	By 1/1/2013
Large fleet – forklift component	26 +	2.4	1.7	1.1
Mid-size fleet – forklift component	4-25	2.6	2.0	1.4
Non-forklift fleet NEW!	N/A	3.0	2.8	2.6
Small fleet	1-3	No uncontrolled equipment by 1/1/2011		

Retrofit Technologies

- Uncontrolled Equipment = High Emissions
  - All pre-2001 and about half of 2001-2003 engines
  - A single uncontrolled forklift operating three shifts = cleanest certified car over its entire life
- Retrofit Technologies Readily Available
  - Available since mid-1990's
  - Applicable to many pre-2001 engines
  - Catalyst and air/fuel feedback control
  - $3,000 installed
  - Improved fuel economy

Purchase New Engines/Equipment

- Replace 12 g engines
- Standards for new engines
  - 3.0 g 2004-2006
  - 2.0 g 2007-2009
  - 0.6 g 2010 and beyond
  - Optional standards
- Readily available / cost-effective emission control technologies
- Cost of a new forklift
  - ~$20,000

Purchase Electric Equipment

- Electric
  - Commercially available
  - Increasingly capable
  - Cost is $2000 - 5000 more than a comparable LSI lift
  - Lower life cycle costs than LSI forklifts
    - (~$1.00 per operating hour)
- Fuel Cells
  - Multiple demonstrations underway

Example Fleet Average Compliance Path - Electric

Forklift Model Year	Percent of fleet	2005
1996	20	12
1998	20	12
2000	20	12
2002	20	12
2004	20	3
Fleet Average		10.2
Standard (large fleet)		n/a

Retrofit New Engine Electric

Example Fleet Average Compliance Path - Electric

Forklift Model Year	Percent of fleet	2005	2009
1996	20	12	0
1998	20	12	0.6
2000	20	12	3
2002	20	12	3
2004	20	3	3
Fleet Average		10.2	1.9
Standard (large fleet)		n/a	2.4

Retrofit New Engine Electric

Example Fleet Average Compliance Path - Electric

Forklift Model Year	Percent of fleet	2005	2009	2011
1996	20	12	0	0
1998	20	12	0.6	0.6
2000	20	12	3	0.6
2002	20	12	3	3
2004	20	3	3	3
Fleet Average		10.2	1.9	1.4
Standard (large fleet)		n/a	2.4	1.7

Retrofit New Engine Electric

Example Fleet Average Compliance Path - Electric

Forklift Model Year	Percent of fleet	2005	2009	2011	2013
1996	20	12	0	0	0
1998	20	12	0.6	0.6	0.6
2000	20	12	3	0.6	0.6
2002	20	12	3	3	0.6
2004	20	3	3	3	3
Fleet Average		10.2	1.9	1.4	1.0
Standard (large fleet)		n/a	2.4	1.7	1.1

Retrofit New Engine Electric

Example Fleet Average Compliance Path - Non-Electric

Forklift Model Year	Percent of fleet	2005
1996	20	12
1998	20	12
2000	20	12
2002	20	12
2004	20	3
Fleet Average		10.2
Standard (large fleet)		n/a

Retrofit New Engine Electric

Example Fleet Average Compliance Path - Non-Electric

Forklift Model Year	Percent of fleet	2005	2009
1996	20	12	2.0
1998	20	12	0.6
2000	20	12	3
2002	20	12	3
2004	20	3	3
Fleet Average		10.2	2.3
Standard (large fleet)		n/a	2.4

Retrofit New Engine Electric

Example Fleet Average Compliance Path - Non-Electric

Forklift Model Year	Percent of fleet	2005	2009	2011
1996	20	12	2.0	2.0
1998	20	12	0.6	0.6
2000	20	12	3	0.6
2002	20	12	3	0.6
2004	20	3	3	3
Fleet Average		10.2	2.3	1.4
Standard (large fleet)		n/a	2.4	1.7

Retrofit New Engine Electric

Example Fleet Average Compliance Path - Non-Electric

Forklift Model Year	Percent of fleet	2005	2009	2011	2013
1996	20	12	2.0	2.0	2.0
1998	20	12	0.6	0.6	0.6
2000	20	12	3	0.6	0.6
2002	20	12	3	0.6	0.6
2004	20	3	3	3	0.6
Fleet Average		10.2	2.3	1.4	0.9
Standard (large fleet)		n/a	2.4	1.7	1.1

Retrofit New Engine Electric

NEW!

Proposal for Non-Forklift Fleets

- New useful life information
  - Ground Support Equipment
- Higher fleet average standards
  - for 2011 and 2013
  - reflect longer useful life data

Proposal for Small Fleets

- Fleets of 1-3 forklifts
- No uncontrolled equipment by January 1, 2011
- Retrofit or replacement
- Low usage exemption
  - 250 or fewer hours per year
  - until January 1, 2013

Agricultural Operations - Alternative Proposal

- Unique economics of agricultural industry
- Applicable to owned forklifts only
- Longer time for clean-up
- Retrofit, retire, or replace ten percent of uncontrolled equipment each year for ten years
- No fleet average (achieve 3.0 g by 2016)
- Lower cost - slow phase-in allows purchase of used 3.0 g equipment
- Hours of use and specialty equipment exemption

Phase-in Schedule

Agricultural Operations - Affected Population

- ~ 2,300 owned forklifts
- ~ 960 replaced or exempt
  - natural turnover (conservatively 3 percent/year)
  - limited hours-of-use and specialty equipment exemptions
- ~ 1,330 remaining forklifts cleaned-up through
  - < 1/3 low-cost retrofit 2007-2010
  - < 1/3 moderate-cost replacement 2010-2012
  - > 1/3 low-cost replacement 2013-2016

Agricultural Operations - Costs

- Retrofits ~ $3,000 each before fuel savings:
  - fuel savings = $400/year with typical usage
  - primarily in calendar years 2007 - 2010
- Moderate cost used 3.0 gram forklift - $5,000-$10,000
  - fuel savings = $400/year with typical usage
  - calendar years 2010 - 2012
- Low cost used 3.0 gram replacement < $4,000
  - fuel savings = $400/year with typical usage
  - calendar years 2013 - 2016

Agricultural Operations - Typical Fleet - 17 Owned Forklifts

- 7 forklifts reduced through natural turnover or limited hour-of-use or specialty exemptions
- 3 retrofitted
- 3 moderate cost replacements
- 4 low cost replacements

Agricultural Operations - Small Fleet - 3 Owned Forklifts

- No requirements until fourth year
- Assume - no forklifts comply through natural turnover or exemptions
- 1 retrofitted
- 2 low cost replacements

Agricultural Operations - Costs

- Average Ag Fleet - 17 forklifts
  - capital cost: $4,700 per year
  - fuel savings: $2,200 per year
- Small Ag Fleet - 3 forklifts
  - capital cost: $1,500 per year
  - fuel savings: $500 per year

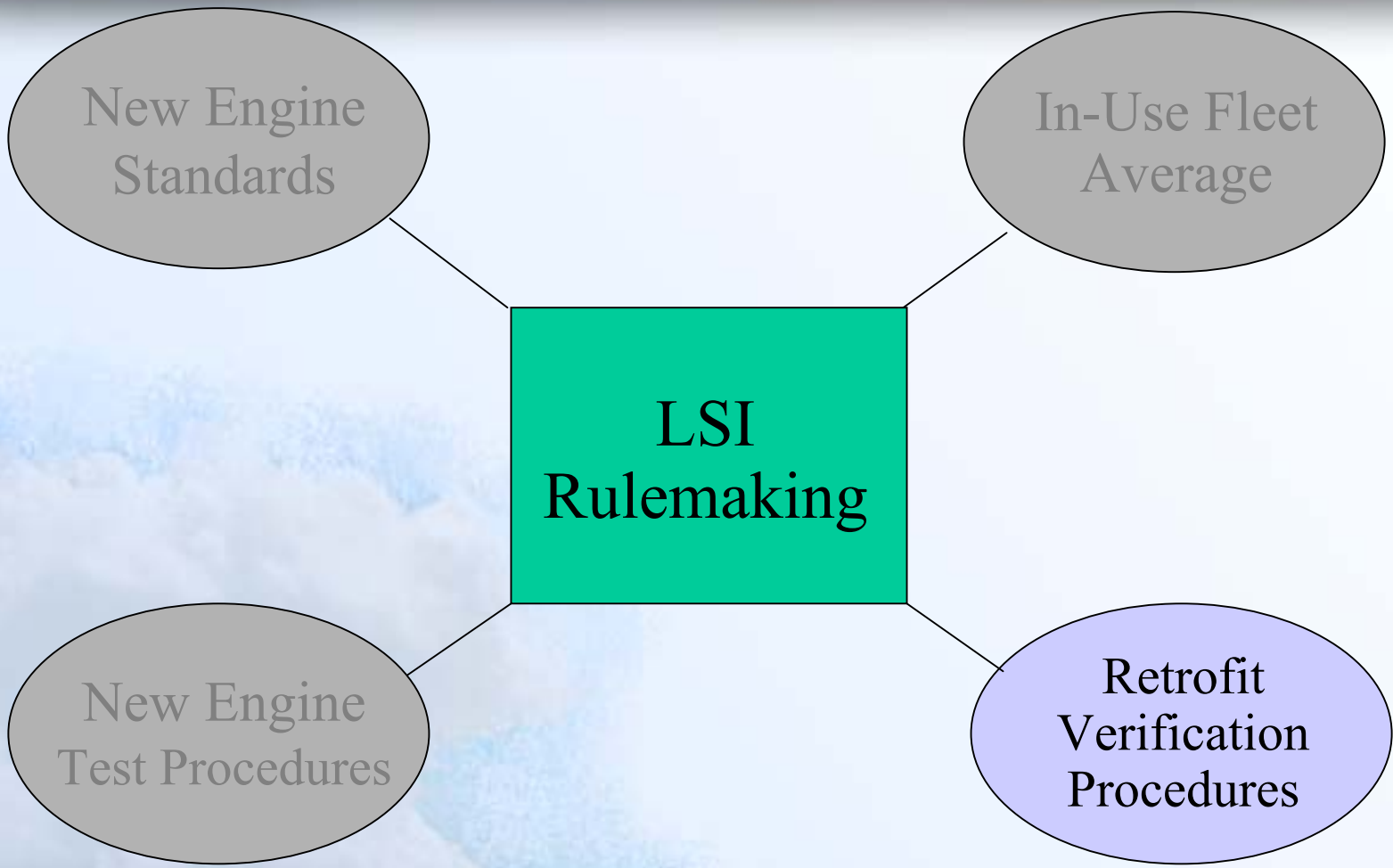
Record Keeping Requirements

- Fleet Average fleets
- Maintain equipment information:
  - type, make, model, serial number
  - emission certification level or retrofit verification level
  - through 12/31/2015
- Maintain LPG fuel information:

NEW!

  - Invoice or other documentation of motor vehicle grade fuel
  - for a period of three years

Elements of the Proposal



Need for Retrofit Verification Protocol

- No procedure for verifying LSI retrofits
- One needed to assure quality and effectiveness of retrofit systems
- Similar to Board-approved diesel retrofit verification program
- May be eligible for Carl Moyer Program incentive grants

Verification Requirements

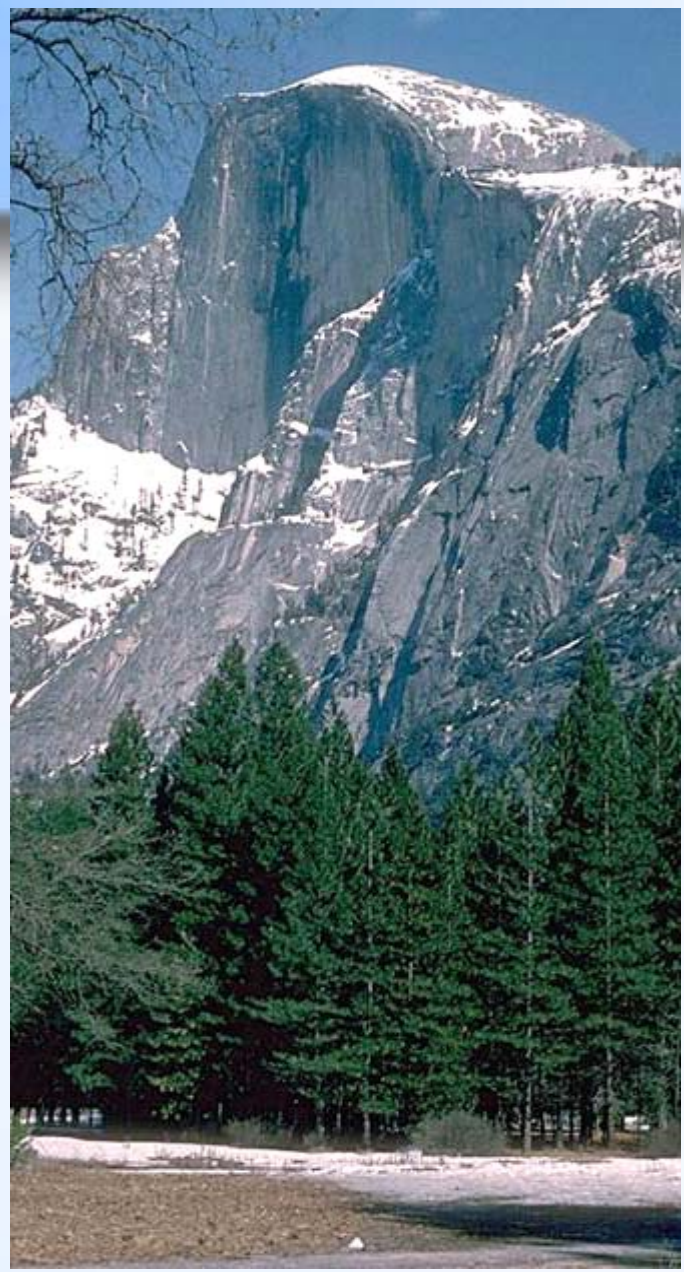
- Applies to manufacturers of LSI retrofit systems
- Verify emission reductions and durability
- Field demonstration
- In-use compliance testing
- Installation and performance warranty
  - 3 years or 2,500 hours
- Labeling requirement

Retrofit Verification Levels

Proposed LSI Engine Retrofit System Verification Levels

Classification	Percentage Reduction (HC+NOx)	Absolute Emissions (HC+NOx)
LSI Level 1	≥ 25%	Not Applicable
LSI Level 2	**≥ 75%**	**3.0 g/bhp-hr**
LSI Level 3a	≥ 85%	0.5, 1.0, 1.5, 2.0, 2.5 g/bhp-hr
LSI Level 3b	Not Applicable	0.5, 1.0, 1.5, 2.0 g/bhp-hr

Estimated Benefits and Cost Effectiveness of the Proposal



Emission Benefit

NEW!

Emission Reductions (HC+NOx)

Year	2010	2020
Tons per day	7.2	6.6
SIP Commitment	6.1 –13.0	3.3 to 11.1

Cost-Effectiveness

Compliance Option	Dollars per pound
Retrofit	0 – 1.00
Lower-emission	0.13
Zero-Emission	0 – 1.40[1]

1. Cost-effectiveness based on replacement of both controlled and uncontrolled equipment.

Issues

- Agricultural fleets
  - Funding
- GSE
  - Useful life and MOU
- Rental Companies
- 2010 Emission Standards
- Fuel quality

Conclusions

- Proposal provides significant emission reductions
- Proposed controls are very cost effective
- Standards are attainable with existing technologies
- Staff recommends Board adoption with proposed modifications